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IS : 4590 - 1980

Indian Standard
SPECIFICATION FOR
SECONDARY LEVEL
(*First Revision*)

REAFFIRMED

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SPECIFICATION FOR SECONDARY LEVEL

(*First Revision*)

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Indian Standard
SPECIFICATION FOR
SECONDARY LEVEL
(*First Revision*)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 30 September 1980, after the draft finalized by the Optical and Mathematical Instruments Sectional Committee had been approved by the Mechanical Engineering Division Council.

0.2 This standard, first published in 1967 as 'Specification for engineers level', has been revised so as to make it applicable exclusively for secondary level. The technical and other requirements covered in the earlier edition have been suitably modified so that it is possible to attain a standard deviation of ± 2 mm in 1 km of double levelling which is the desired accuracy for secondary levelling. The requirements of primary and tertiary levels have been separately covered in IS : 9613-1980* and IS : 9607-1980†.

0.3 Secondary level is a medium accuracy level used for second order levelling operations. These operations are undertaken for height determination for topographical works, installation of machinery, construction of roads and railways, building works, etc.

0.4 Secondary level (see Fig. 1) consists of an internal focussing telescope having medium magnification and resolution. These levels are normally of two types, namely tilting level and automatic level. The tilting level is one in which the axis is approximately levelled with a small circular bubble and more accurate levelling is done by centring a more sensitive bubble by means of a tilting screw. The automatic type is one in which the axis is approximately levelled by a circular bubble and more accurate levelling of axis is achieved automatically by a prism system suspended under gravity inside the instrument. This standard deals with the tilting type level.

*Specification for primary level.

†Specification for tertiary level.

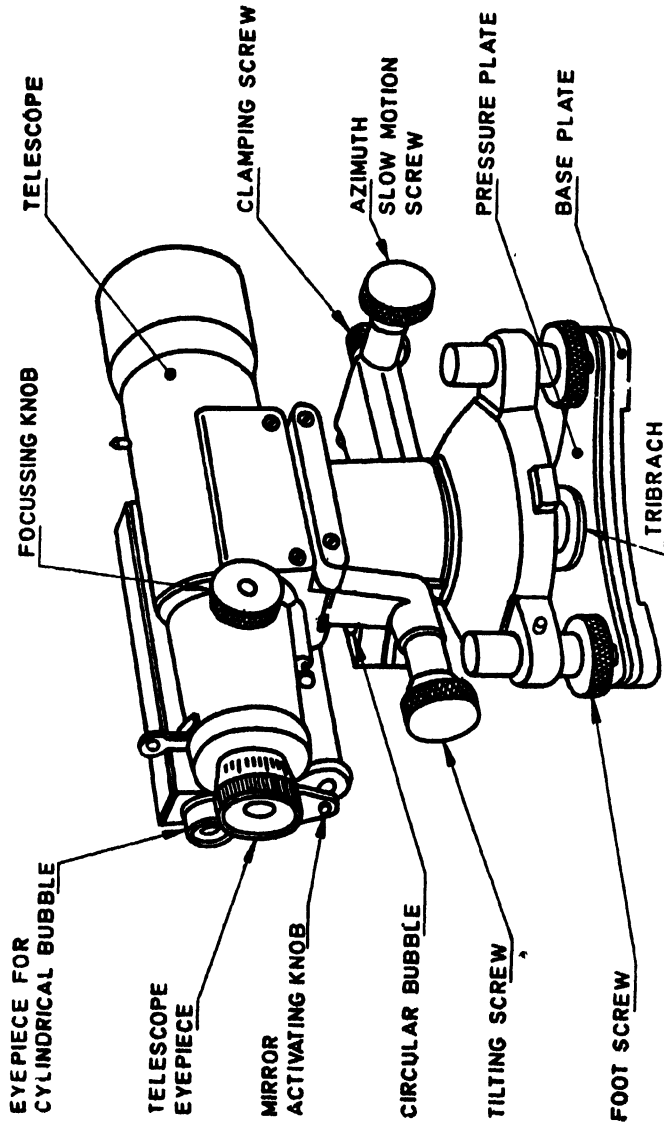


FIG. 1 SECONDARY LEVEL

1. SCOPE

1.1 This standard specifies the requirements of tilting type secondary level capable of attaining standard deviation (mean square error) of ± 2 mm in 1 km of double levelling.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions and the definitions given in IS : 1399-1959* shall apply.

2.1 Levelling Staff — A vertical wooden rod having divisions (see IS : 1779-1961†).

2.2 Tribrach — The lowest part of a level carrying the levelling-cum-mounting system.

3. GENERAL REQUIREMENTS

3.0 The secondary level shall conform to the requirements laid down in IS : 988-1959‡ and to the requirements laid down in 3 of IS : 2754-1964§.

3.1 The base plate of the instrument shall have provision for fitting the level on the stand. It shall have a central hole of such dimension that a clamping screw of size M16 \times 2 may be fitted well into it.

3.2 A pressure plate shall be provided to keep the foot screws firm in the sleeves of the base plate.

3.3 The level shall be provided with a cylindrical axis and bushing made of special high grade alloy steel which ensures reliable operation at any temperature without special attention to oiling, cleaning and adjustment, etc.

3.4 The instrument shall be compact, solid and highly stable.

3.5 All optical parts shall be provided, except the face marked with graticule markings, with antireflection coatings. The quality of antireflection coating shall conform to IS : 8248-1976||.

3.6 Bubbles

3.6.1 The bubbles provided with the level shall conform to the requirements of IS : 1632-1960¶ as far as applicable.

*Glossary of terms used in optical technology.

†Specification for 4-metre levelling staff, folding type.

‡General requirements for optical components.

§General requirements for optical instruments.

||Specification for antireflection coating on glass optical components.

¶Specification for bubbles.

3.6.2 The instrument shall be provided with a circular bubble for quick levelling in the beginning. It may be fitted with a plane circular reflector (mirror) for ease of observations of the air bell. The bubble shall be provided with capstan or square head screw for adjustment. This type of screw shall be adopted to enable the use of tommy pin/spanner during adjustment and thus avoiding undue pressure on bubble.

3.6.3 The level shall be fitted with a cylindrical bubble having provision of a plane mirror. In order to facilitate its use in different lighting conditions, one side of the mirror shall have a good reflecting surface. The plane mirror shall be fitted over the bubble in such a way that it can easily be retained in any position and shall not fall due to its own weight. The cylindrical bubble shall be capable of adjustment by means of capstan or square head screw.

3.6.4 Provision shall be made to see the two ends of cylindrical bubble by coincidence principle. This shall be achieved by means of prisms. An eyepiece shall be provided to see the coincidence of bubble ends.

3.6.5 The cylindrical bubble shall be capable of adjustment by means of capstan or square head screw.

3.7 Horizontal Circle — If agreed to between the supplier and the purchaser, the level shall be provided with a horizontal glass circle. The circle shall be graduated in 360° with provision to read directly 10' and by estimation 1'. The figuring shall be done at each degree.

3.8 Telescope

3.8.1 The telescope shall be provided with an internal focussing arrangement and its optics shall be provided with antireflection coating conforming to IS : 8248-1976*.

3.8.2 The graticule of the telescope shall be provided with cross and stadia lines, the latter being provided in the vertical cross line. The distance of stadia lines from the horizontal cross line shall be equal. Provision shall be made for adjusting collimation of the telescope both in the field and the laboratory.

3.8.3 The telescope shall be provided with a clamping screw, a screw for slow motion in the horizontal plane and a tilting screw for slow motion in the vertical plane. The head of the tilting screw shall be graduated and figured suitably to facilitate at the time of adjustment of bubbles as given in 5.2.1.1.

3.8.4 A sighting arrangement shall be provided on the telescope for quick alignment with the staff.

*Specification for antireflection coating on glass optical components.

3.9 Technical Data

3.9.1 The secondary level shall conform to the following technical requirements:

a) Magnification	25 to 30 ×
b) Clear aperture of objective	40 mm
c) Field of view	About 1.5 degrees
d) Addition constant	Practically 0
e) Multiplication (stadia) constant	100
f) Shortest sighting distance	About 1.6 m
g) Largest aiming distance for mm evaluation	100 m
h) Levelling accuracy attainable that is standard deviation (mean square error) in 1 km of double levelling	± 2 mm
j) Accuracy of levelling the line of sight	± 0.8 seconds
k) Sensitivity of circular bubble	10 minutes per 2 mm
m) Sensitivity of cylindrical bubble	30 seconds per 2 mm
n) Horizontal circle's graduations	(see 3.7)

3.10 Case — The instrument shall be provided with a light metallic or well seasoned wooden case fitted with receptacles to hold the instrument and accessories. The case shall have suitable locking arrangement. A carrying handle or belt shall be provided with the case.

3.11 Accessories — The following accessories shall be supplied with each instrument:

a) Camel hair brush	1
b) Tommy pin/spanner	2
c) Chamois leather	1 piece
d) Silica gel	1 bag of about 200 g
e) Screw driver	1
f) Tripod with clamping screw and plumb bob	1

4. FUNCTIONAL REQUIREMENTS

4.1 The movement of the clamping, slow motion and tilting screws and the motion of the different parts of the instrument shall be easy and smooth without undue stiffness, looseness or backlash.

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4.2 The clamping screw shall be such that it does not exert any strain on the clamped parts.

4.3 The motion of foot screws shall be smooth and these shall be protected from dust.

4.4 The rotation of the telescope on its vertical axis shall be strain-free and smooth.

4.5 The mount for the cylindrical bubble shall be adjustable both sideways and in the vertical plane.

4.6 The capstan screws provided for adjustment of different part shall be such as not to exert any undue pressure on the respective parts.

5. TESTS

5.1 General Requirement Tests

5.1.1 External — The level shall be initially checked for the following external defects:

- a) Loose, missing or damaged screws, nuts and other small parts; and
- b) Damage to telescope, bubble, engraving and external finish, etc.

5.1.2 Internal — The instrument shall be checked for the following internal defects:

- a) Scratched, chipped or dirty optics;
- b) Damage to optical parts, graticule, deterioration of optical cement and antireflection coatings;
- c) Filming or fungus growth on optical surfaces; and
- d) Cloudiness or milky appearance on lenses and lack of clarity of graticule lines, etc.

5.1.3 The level shall be checked for smooth and adequate movement of different parts.

5.1.4 Mechanical

5.1.4.1 Clear aperture — The clear aperture of the objective shall be measured by a slide gauge or any suitable device. The measured value shall conform to the specified value.

5.1.4.2 Bubbles — The sensitivity, consistency and all other parameters of the bubbles shall be tested in accordance with 6.1 to 6.7 of IS : 1632-1960* and the values so obtained shall conform to the specified values within the tolerances laid down in Table II of IS : 1632-1960*.

*Specification for bubbles.

5.1.5 Optical

5.1.5.1 Graticule alignment — The alignment of the graticule shall be tested with the help of a collimator and any misalignment shall be corrected by seeing the collimator's graticule.

5.1.5.2 Definition — The definition of the telescope shall be tested with the help of a definition board given in Appendix E of IS : 2754-1964*. The circles, lines and squares of the board shall appear sharply defined without any distortion and colour over at least two-thirds of the field of view. The definition and freedom from colour and distortion over the remaining field shall also be reasonably satisfactory.

5.1.5.3 Magnification — The magnification of the telescope shall be tested by the methods specified in Appendix C of IS : 2754-1964*. The measured value shall not differ by more than 5 percent from the specified value.

5.1.5.4 Resolving power — The resolving power of the telescope shall be measured by the method specified in Appendix F of IS : 2754-1964*. The measured value shall not differ by more than 5 percent from the specified value.

5.1.5.5 Parallax — The level shall be tested for parallax with the help of collimator. After levelling the instrument with the help of two bubbles, the telescope shall be focussed on the collimator's graticule. There shall not be any apparent movement between the image of the collimator's graticule and the telescope's graticule on viewing the former through the eyepiece and moving eye at right angles to the axis of eyepiece.

5.1.5.6 Collimation — The collimation shall be tested in the laboratory with the help of a collimator. The instrument shall be accurately levelled with the help of the two bubbles† provided and the collimator's graticule shall be focussed by it. Any deviation in the coincidence of image of the collimator's graticule and telescope graticule shall represent collimation error. This shall be corrected by moving the graticule with the help of adjusting screws provided in its mount.

5.1.5.7 The field of view of the telescope shall be tested by the method specified in Appendix D of IS : 2754-1964*. The measured value shall not differ by more than 5 percent from the specified value.

5.1.5.8 Strain — The optics of the telescope shall be free from strain. It shall be tested as under:

The level shall be so held that its telescope is in the path of light between two crossed nicols in a sensitive polariscope or strain

*General requirements for optical instruments.

†The bubbles shall be first adjusted as given in 5.2.1.1.

viewer. The strain present in the telescope shall be revealed by the colour of the transmitted light. Before introducing the telescope of the level, the nicols shall be set for magenta colour. The strained areas in the optics of the telescope shall not show colour beyond indigo in the optical spectrum.

5.2 Operational Tests

5.2.1 General

5.2.1.1 Bubbles — The instrument shall be placed on a perfectly flat and firm surface. The telescope shall be put parallel to any two foot screws facing the observer and the instrument shall be levelled by these two foot screws using the cylindrical bubble only. The bubble shall be seen in U-shape in this situation. This shall be called the first position. The telescope shall then be rotated through 90° from this position in the clockwise direction and levelled (U-shape made) with the help of the third foot screw only. This shall be called the second position. The telescope shall then be rotated through 90° from the second position in clockwise direction so that it becomes again parallel to the first two foot screws as in the beginning (first position). The instrument shall then be levelled by making U-shape of the bubble, half with the help of two foot screws and half by using the tilting screw of the telescope. This process shall be repeated (that is, to level in the first position, half by two foot-screw parallel to telescope and half by tilting screw while in the second position by the third foot screw only) till cylindrical bubble is perfectly levelled in all the positions of the telescope (that is, U-shape is not disturbed in all the positions of the telescope).

The circular bubble shall then be brought in centre with the help of its adjusting screws without using foot screws and tilting screw till it remains in centre in all the positions of the instrument.

5.2.1.2 Reading accuracies

- a) The instrument shall be focussed on an appropriate vertical staff and the readings with three graticule lines shall be taken. The mean of the three readings shall agree with the middle line readings within 0.9 mm.
- b) The height difference between two staff points shall be determined by the level in its two different set ups on the same station. The two values shall agree within 1.2 mm.

5.2.2 Field Test of Collimation — The collimation shall be tested in the field by making observations on appropriate staves at equal and unequal distances. The two staves shall be placed 80 m apart and the instrument shall be placed in the middle of the line, that is at 40 m from each staff. The difference in heights of the two staff points, say X , shall be determined

in this situation. The instrument shall then be shifted to another point in the line such that the distance of one staff is 20 m while that of the other staff is 60 m from the instrument; retaining the staves precisely on their original points. The difference in heights, say Y , of the two staff-points shall again be determined in this situation. In case, there is no collimation error, the height difference as determined in both the positions of the instrument shall remain the same within a tolerance of 1.0 mm. Beyond this limit, the collimation error shall be corrected as follows:

For this, the instrument (at this position of unequal staff distances) shall be focussed on the farther staff, say B , and the horizontal wire is made to intersect the farther staff B at original reading $+ (Y - X) \times \frac{2}{3}$ by means of micrometer screw. This will disturb the bubble which should be brought to the centre of its run by means of capstan or square head screw at the end of the bubble tube.

5.2.3 Field Test for Determination of Standard Deviation — The standard deviation (error) of the level shall be determined by the test method given in Appendix A.

5.3 Climatic and Environmental Test

5.3.1 The following tests shall be carried on as given in IS : 2352-1963*. These are only type approval tests to be carried on sample basis as agreed to between the purchaser and the manufacturer. These are not to be used in routine testing during bulk production.

5.3.2 Temperature Test — The level shall be subjected to cold and dryheat test on severities — 10°C and 55°C respectively and checked thereafter for collimation, parallax, deterioration of cementing and antireflection coating.

5.3.3 Rain Test — The level, in its case, shall be tested in a rain chamber and after the test the level shall be checked for ingress of moisture or water drops and for deterioration to any part of the instrument.

5.3.4 Fungus (Mould) Growth Test — The level shall be tested for the fungus growth and checked thoroughly after the test.

5.3.5 Vibration Test — The level, in its case, shall be clamped on to a vibration table giving approximately 450 vibrations per minute with an amplitude of 3 mm for a period of 5 minutes. After the test, the instrument shall be in perfect adjustment.

*Procedure for basic climatic and durability tests for optical instruments.

6. MARKING

6.1 The level shall be marked with the manufacturer's name or trade-mark and the year of manufacture.

6.1.1 Level may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

7. PACKING

7.1 The level shall be placed in its case together with its accessories and also an instruction booklet containing the guidelines for its use and adjustment. The case shall be suitably packed for transit.

APPENDIX A

(*Clause 5.2.3*)

METHOD OF TESTING STANDARD DEVIATION (ERROR) OF LEVEL

A-1. PROCEDURE

A-1.1 In order to test for standard deviation, the following requirements shall be fulfilled:

- a) Instrument concerned in good adjustment.
- b) Good staves and experienced staffmen.
- c) Good and experienced observers.
- d) Four test lines (legs) connecting at least four and maximum five bench marks, established by levelling of high precision. The length of each leg shall be 250 m so that the total length of levelling line may be 1 km. The bench marks shall be selected in such a way that the four differential heights may be between 0.5 m to 2.5 m.

A-1.2 The four test legs (l_a , l_b , l_c and l_d) shall be used in either of the following patterns (p), (q) or (r) (see Fig. 2).

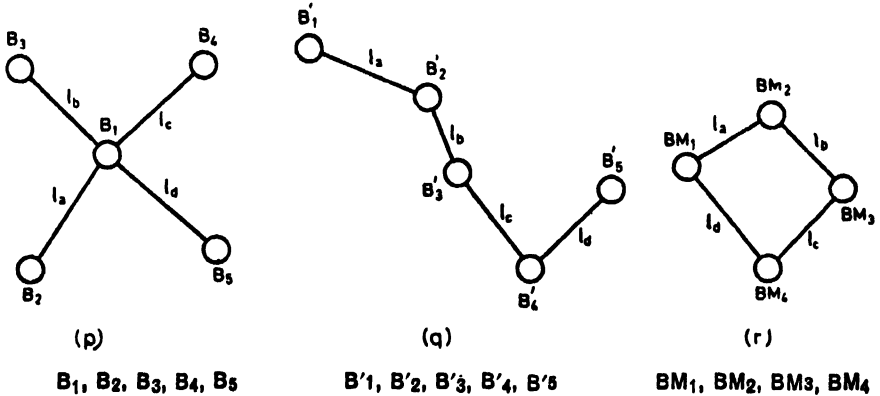


FIG. 2

$B_1, B_2, B_3, B_4, B_5, B'1, B'2, B'3, B'4, B'5, BM_1, BM_2, BM_3$ and BM_4 denote the bench marks. It may be seen that patterns (p) and (q) shall involve five bench marks while (r) shall involve only four bench marks.

A-1.3 On each test leg five fore and five back levellings shall be carried on so that 10 differential heights may be observed. The mean of these measurements shall be calculated and deviations of each value from the mean found out. The squares of deviations shall be taken and sum of such 10 squares of deviations shall be found out in case of each leg. These shall be denoted as $\Sigma v^2 l_a, \Sigma v^2 l_b, \Sigma v^2 l_c$ and $\Sigma v^2 l_d$. If Σv^2 is denoted as the sum of the squares of deviations on four legs, then $\Sigma v^2 = \Sigma v^2 l_a + \Sigma v^2 l_b + \Sigma v^2 l_c + \Sigma v^2 l_d$. The standard deviation shall be calculated by the formula:

$$S \text{ per km of double levelling} = \pm \sqrt{\frac{\Sigma v^2}{18}}$$

A-2. PRECAUTIONS

A-2.1 While carrying out the above test the following precautions shall be observed:

- a) The discordance between the fore and back values shall be kept within the specified tolerance for that particular type of level.
- b) All usual precautions and errors shall be strictly taken into consideration.

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(Continued from page 2)

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(First Revision)

(Page 6, clauses 3.6.3 and 3.6.4) — Substitute the following for the existing clauses:

'3.6.3 The level shall be fitted with a cylindrical bubble having provision of a plane mirror. In order to facilitate its use in different lighting conditions, one side of the mirror shall have a good reflecting surface. The plane mirror shall be fitted over the bubble in such a way that it can be easily retained in any position and shall not fall due to its own weight. The cylindrical bubble shall be capable of adjustment by means of capstan or square head screw. Alternatively, provision shall be made to see the two ends of cylindrical bubble by coincidence principle. This shall be achieved by means of prisms. An eyepiece shall be provided to see the coincidence of bubble ends.'

(Page 6, clause 3.6.5) — Renumber this clause as 3.6.4.

(LM 10)